Estimating Cross-Price Elasticity of Demand and Cross-Income Elasticity of Demand for Atlantic Salmon (Salmo salar) Cultured in British Columbia

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ABSTRACT

The elasticity of demand measures the sensitivity of the demand for a good or service when the price of a good or service changes. This ratio is generally negative because when the price rises, the quantity demanded decreases and vice versa. The cross-price elasticity is defined as the ratio of the percentage change in quantity demanded of good A and the percentage change in the price of good B and determines whether goods A and B are either "substitute goods" or "complementary goods". The cross-income elasticity of demand is defined as the ratio of the percentage change in the demand for a good to the percentage change in consumer income. There are three classifications of goods: inferior goods, normal goods and superior goods. A regression analysis was performed to estimate cross-price elasticity of demand for cultured Atlantic salmon measured against the price of wild Pacific salmon and the cross-income elasticity of demand for cultured Atlantic salmon measured against the per capita Gross National Income in Canada from the years 1985 to 2012. The results of the regression analysis indicate that no species of wild Pacific salmon acts as a substitute good for cultured Atlantic salmon and that cultured Atlantic salmon is a superior good.

RÉSUMÉ

L'élasticité de la demande mesure la sensibilité de la demande pour un bien ou service, lorsque le prix d'un bien ou service change. Ce rapport est généralement négatif car lorsque le prix augmente, la quantité demandée diminue et réciproquement. L'élasticité prix croisés est définie comme le rapport entre le pourcentage de variation de la quantité demandée de bien A et le pourcentage de variation du prix d'un bien B, lorsque les biens A et B sont des biens dits « de substitution » ou des biens dits « complémentaires ». L'élasticité-revenu croisée est définie comme le rapport entre le pourcentage de variation de la demande d'un bien et le pourcentage de variation du revenu. On distingue trois catégories de biens: les biens inférieurs, les biens normaux et les biens supérieurs. Une analyse de régression a été effectuée pour estimer l'élasticité prix croisée de la demande pour le saumon de l'Atlantique, mesurée contre le prix du saumon sauvage du Pacifique et de l'élasticité-revenu croisée de la demande pour le saumon de l'Atlantique, mesurée par rapport au par habitant revenu national brut au Canada à partir des années 1985 à 2012. les résultats de l'analyse de régression indiquent qu'aucune espèce d'actes de saumon sauvage du Pacifique comme un bon substitut pour le saumon atlantique d'élevage et que le saumon de l'Atlantique, est un bien supérieur.

INTRODUCTION

Elasticity of demand is concept used in economics to describe the short term price sensitivity of a good by measuring the change in the quantity of the good demanded by consumers in response to a change in the price of the good. Mathematically, elasticity of demand may be calculated by the equation:

$$e = \frac{\Delta Q/Q}{\Delta P/P} \qquad (1)$$

Usually this is an inverse relationship: as the price increases the quantity demanded will decrease. A good that experiences a large change in quantity demanded as a result of a small change in price is referred to as being price elastic (fig 1). These tend to be non-essential and highly discretionary goods that are readily available but not necessities. A good that experiences a small change in quantity demanded as a result of a large change in price is referred to as being price inelastic (fig 2). Many types of fuels are price inelastic. For example, in the short term commuters will continue to buy gasoline in spite of rising prices. In the long term, commuters may switch to more fuel efficient cars or move closer to work creating a new demand curve.

Cross-price elasticity measures the change in quantity demanded of good as a result of a change in the price of another good under the condition of *ceteris paribus* (all things remaining equal). In such a case, the goods in question are either considered as substitute goods or complementary goods. Substitute goods share similar characteristics or functions such that they may easily replace each other. Butter and margarine are two goods that act as substitutes for each other. If the price of butter rises then consumers will purchase margarine as a substitute and the quantity of margarine demanded will increase. Thus, an increase in the price of a good will also cause an increase the quantity demanded of its substitute. When the function of one good depends upon another good or when two goods depend upon the function of each other, the goods are called complementary goods. Ski boots and skis are complementary goods as are earphones and audio devices. If the price of skis increases then the quantity demanded of skis will decrease as too will the quantity demanded of ski boots. Therefore, the cross-price elasticity for substitute goods will be positive while the cross-price elasticity of complementary goods will be negative as illustrated in table 1

Cross-income elasticity measures the change in quantity demanded of a good as a result of a change in consumer income *ceteris paribus*. This measure of elasticity is used to determine whether a good is an inferior good, a normal good or a superior good. Inferior goods display a decrease in quantity demanded as a result of an increase in consumer income. Instant noodles, for example, are a popular food among

cash-strapped students. When the students graduate and enter the workforce, their incomes rise and their appetite and demand for instant noodles decreases. Thus instant noodles may be considered as an inferior good. A normal good is one that experiences either no increase or only a modest increase in quantity demanded as a result of an increase in consumer income. Normal goods are sometimes called *necessary goods* and are comprised mostly of staple products such as food. Superior goods are those goods that experience a large increase in quantity demanded as a result of rising consumer income. Luxury goods such as fashion items and vacation packages are examples of superior goods. Cross-income elasticity will therefore have a negative sign for inferior goods, a positive but a small magnitude for normal goods and positive sign with a large magnitude for superior goods as illustrated in table 2.

Elasticity of demand is a useful tool for managers and producers as it helps to identify competitive goods and to determine price entry points for their products. There have been attempts in the past to estimate elasticity of demand for Canadian salmon and other seafood species. De Voretz (1982) constructed an econometric demand model for canned Pacific salmon which included a calculation of cross-income elasticity of demand and cross-price elasticity of demand using canned tuna as a substitute good. The model indicated that canned Pacific salmon is a normal good and that canned tuna acts as a substitute good. An exhaustive study undertaken by Singh, Dey and Surathkal (2012) utilized store level scanner data to calculate the cross-price elasticity of demand for a number of frozen seafood species sold at market. The authors discovered that some species of shellfish may act as substitutes for certain species of finfish. Chidmi, Hansson and Nguyen (2012) performed a similar study that tested for substitute goods across marine, freshwater, shellfish and finfish species and created a table of cross-price and own price elasticity.

The purpose of this report is to estimate the elasticity of demand, cross-income elasticity of demand and cross-price elasticity of demand for Atlantic salmon (Salmo salar) cultured in British Columbia in order to determine: its price sensitivity, whether it is an inferior good, normal good or superior good and to determine whether any species of wild Pacific salmon acts as a substitute good for cultured Atlantic salmon.

METHODOLOGY

Annual data pertaining to landings, landed values, aquaculture production and farm gate value were obtained from the *Seafood Industry Year in Review* for the years 1985 to 2012 as published by the Province of British Columbia. Landings recorded in tonnes and landed value recorded in dollars for the five wild Pacific salmon species: Chinook,

chum, coho, pink and sockeye for each year were tabulated on an Excel spreadsheet. The aquaculture production measured in tonnes and the farm gate value measured in dollars for Atlantic salmon cultured in British Columbia for each year were also entered into the spreadsheet. Lastly, the Gross National Income per capita for Canada for each year between 1985 and 2012 was obtained from the World Development Indicators database published by the World Bank and was entered into the spreadsheet.

The quantity dependent model is defined as:

$$Q^x_t = A(P^x_t)^b(Y_t)^c \qquad (2)$$

where Q^x_t is the equilibrium quantity demanded and supplied to market of a species of salmon denoted by superscript x in each annual time period, P^x_t is the price of a salmon species denoted by superscript x in each annual time period and Y_t is the per capita GNI for Canada during each of the annual time periods. The intercept term is given by A while b and c represent parameters for price and income respectively.

Equation (2) may be restated in the form:

$$\ln(Q^x_t) = \ln(A) + (b)\ln(P^x_t) + (c)\ln(Y_t) \qquad (3)$$

When measured across multiple time periods, the coefficients b and c in equation (3) represent price elasticity of demand and income elasticity of demand respectively. This is true because the derivative of the natural log of x is simply the inverse of x or:

$$\ln(x)dx = \frac{1}{x} \qquad (4)$$

$$\ln(x) = \frac{dx}{x} = \frac{\Delta x}{x} \qquad (5)$$

Holding other terms equal, coefficient b in equation 3 may be expressed as:

$$b = \frac{\ln(Q)}{\ln(P)} = \frac{\Delta Q/Q}{\Delta P/P} \qquad (6)$$

The same argument can be made to show that coefficient c represents cross-income elasticity of demand. When the species denoted by superscript x is the same for both the dependent and independent variables in equation (3), the coefficient b represents the species own elasticity of demand. When equation (3) is expressed in the form:

$$\ln(Q^x_t) = \ln(A) + (b)\ln(P^y_t) + (c)\ln(Y_t) \qquad (7)$$

where the superscripts x and y represent two different species of salmon, then the coefficient b represents the cross-price elasticity of demand.

Equation (7) may be used to form the following estimating equation:

$$\ln(Q^A_t) = B_0 + B_1\ln(P^S_t) + B_2\ln(Y_t) + \varepsilon \qquad (8)$$

where Q^A_t is the quantity of cultured Atlantic salmon demanded in time period t measured in tonnes, P^S_t is the price of a substitute salmon species in period t measured in dollars per kilogram and Y_t is the GNI per capita in Canada in time period t measured in dollars and ε is the stochastic error term.

If the price of wild Pacific salmon is inserted into the variable P^S_t, then the coefficient B_1 in equation (8) is the cross-price elasticity of demand for cultured Atlantic salmon when measured against the price of wild Pacific salmon. Since cultured Atlantic salmon and wild Pacific salmon share similar characteristics and functions they are potential substitute goods. If the coefficient B_1 in equation (8) has a positive sign for any species of wild Pacific salmon inserted into variable P^S_t then that species is a substitute good for cultured Atlantic salmon. On the other hand, if the coefficient B_1 in equation (8) has a negative sign then we cannot conclude the species of wild Pacific Salmon used in variable P^S is a complementary good since wild Pacific Salmon is not dependent upon cultured Atlantic salmon for its function nor vice versa. When the price of Atlantic salmon is inserted into the variable P^S_t, the coefficient B_1 represents Atlantic salmon's own elasticity of demand. If the coefficient B_2 in equation (8) takes a negative sign then cultured Atlantic salmon is an inferior good. On the other hand, if the coefficient B_2 in equation (8) takes positive sign but is less than 1 in magnitude then cultured Atlantic salmon is a normal good. Finally, if the coefficient B_2 in equation (8) takes a positive sign but is greater than 1 in magnitude then cultured Atlantic salmon is a superior good.

ANALYSIS

Table 3 displays the coefficients and their associated p-values enclosed in parentheses for a regression analysis performed on the estimating model given in equation (8). For all species of wild Pacific salmon, the cross-price elasticity of demand has a negative sign indicating that none of these species is a substitute good for cultured Atlantic salmon. The cross-income elasticity of demand shows a positive sign in all estimated equations with a magnitude greater than 1. Only the cross-price elasticity of demand for coho, sockeye and Atlantic salmon's own elasticity of demand are not significant to the 5 percent level of significance. All coefficients, however, are significant to the 10 percent level of significance. Since no variable takes a zero value in the sample, the intercepts produced by the estimates are meaningless. Finally, no significant multicollinearity or heteroskedasticity were detected in any of the estimated equations.

CONCLUSION

The magnitude of Atlantic salmon's own elasticity of demand (-2.39) indicates that cultured Atlantic salmon is highly elastic. For example, if the price of cultured Atlantic salmon were to increase by 1% then the quantity demanded would be expected to decrease by almost 2.5%. Since the ratio of the change in quantity demanded to the change in price is greater than unity, it can be concluded that cultured Atlantic salmon is a price sensitive good. The cross-price elasticity of demand for cultured Atlantic salmon returned a negative sign indicating that none of the wild Pacific salmon species included in the estimated equation were substitute goods. The cross-income elasticity of demand for cultured Atlantic salmon returned a coefficient with a positive sign for each of the estimated equations. Furthermore, the magnitude of cultured Atlantic salmon's cross-income elasticity of demand indicates that it is highly income elastic such that a 1% increase in average income would result in more than a 7% increase in quantity demanded and therefore Atlantic salmon may be considered as a superior good.

REFERENCES

British Columbia. Fisheries production statistics of British Columbia 1996. Victoria: Queen's Printer, 2000.

British Columbia. Seafood industry year in review (Vols.1998-2012). Victoria: Queen's Printer.

Chidmi, B., Hanson, T., Nguyen, G. 2012 Substitutions between fish and seafood products at the US national retail level. Marine Resource Economics. 27:359-370

De Voretz, D. 1982. An econometric demand model for Canadian salmon. Canadian Journal of Agricultural Economics. 30:49-60

Singh, K., Dey, M.M., Surathkal, P. 2012. Analysis of a demand system for unbreaded frozen seafood in the United States using store-level scanner data. Marine Resource Economics. 27:371-387

The World Bank. *World Development Indicators. GNI per capita (constant LCU),* n.d. web, 2 Dec 2014.

APPENDIX

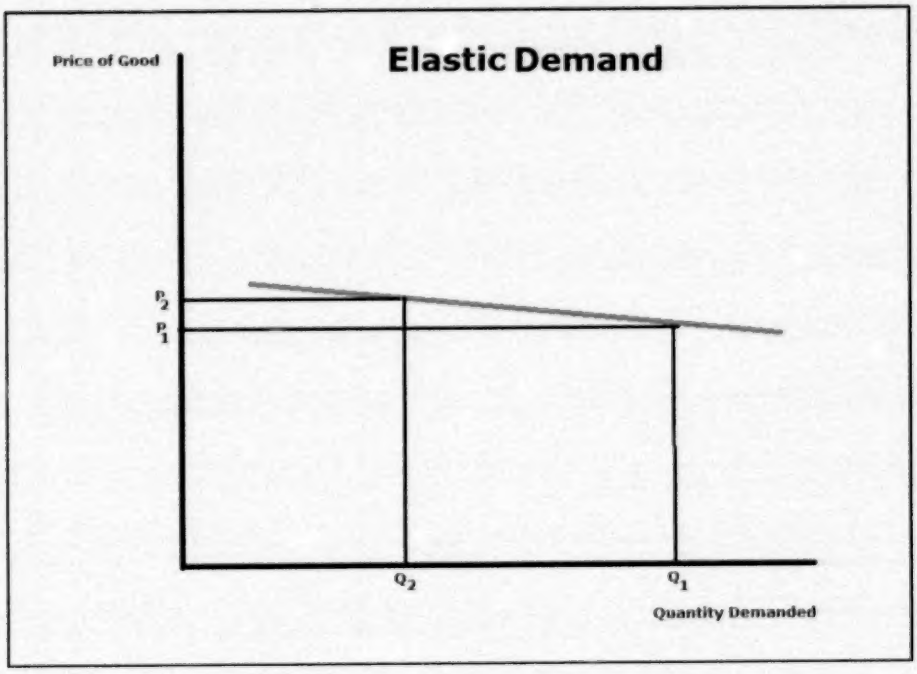

Figure 1

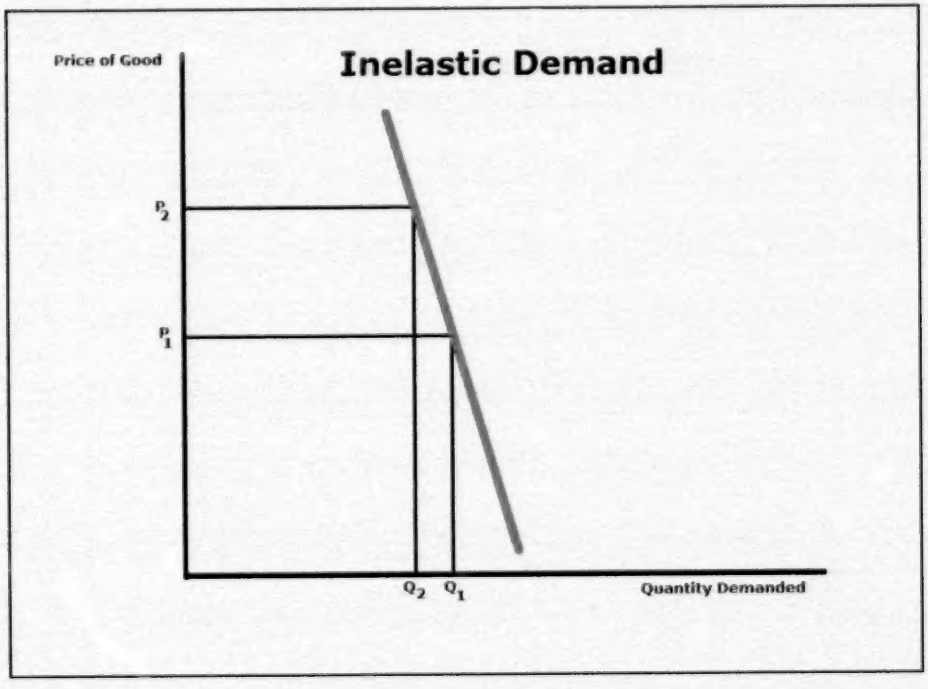

Figure 2

Table 1. Cross-Price Elasticity

Type of Good	Price of Good A	Quantity of Good B Demanded	Elasticity (e)
Substitute	Increases	Increases	e>0
Complimentary	Increases	Decreases	e<0

Table 2. Cross-Income Elasticity

Type of Good	Average Income	Quantity of Good Demanded	Elasticity (e)
Inferior good	Increases	Decreases	e<0
Normal good	Increases	Increases	0<e<1
Superior good	Increases	Increases	e>>1

Table 3. Estimated Coefficients

Substitute Species	Cross-Price Elasticity	Cross-Income Elasticity	Intercept	R^2
Chinook	**-3.02** (0.00)	**15.54** (0.00)	**-148.84** (0.00)	**0.736**
chum	**-0.93** (0.03)	**8.69** (0.00)	**-81.59** (0.00)	**0.638**
coho	**-0.58** (0.08)	**9.97** (0.00)	**-94.64** (0.00)	**0.616**
pink	**-1.56** (0.01)	**6.62** (0.00)	**-60.62** (0.00)	**0.671**
sockeye	**-1.83** (0.09)	**9.27** (0.00)	**-85.01** (0.00)	**0.597**
Atlantic[1]	**-2.39** (0.07)	**7.11** (0.00)	**-60.96** (0.00)	**0.615**

Note 1 – this is Atlantic salmon's own elasticity of demand

Regressions

Dependent Variable: Ln($Q_{Atlantic}$)
Method: Least Squares
Date: 11/21/14 Time: 20:41
Sample (adjusted): 4 28
Included observations: 25 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-148.8402	20.94523	-7.106162	0.0000
Ln(Y)	15.53517	2.073179	7.493402	0.0000
Ln($P_{chinook}$)	-3.023600	0.778845	-3.882160	0.0008

R-squared	0.736827	Mean dependent var	9.992502
Adjusted R-squared	0.712902	S.D. dependent var	1.668266
S.E. of regression	0.893883	Akaike info criterion	2.725682
Sum squared resid	17.57857	Schwarz criterion	2.871947
Log likelihood	-31.07102	Hannan-Quinn criter.	2.766250
F-statistic	30.79754	Durbin-Watson stat	0.541269
Prob(F-statistic)	0.000000		

Dependent Variable: Ln($Q_{Atlantic}$)
Method: Least Squares
Date: 11/21/14 Time: 20:39
Sample (adjusted): 4 28
Included observations: 25 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-81.59180	18.08531	-4.511496	0.0002
Ln(Y)	8.693245	1.714986	5.068990	0.0000
Ln(P_{chum})	-0.929962	0.417576	-2.227049	0.0365

R-squared	0.638122	Mean dependent var	9.992502
Adjusted R-squared	0.605224	S.D. dependent var	1.668266
S.E. of regression	1.048192	Akaike info criterion	3.044177
Sum squared resid	24.17153	Schwarz criterion	3.190442
Log likelihood	-35.05221	Hannan-Quinn criter.	3.084744
F-statistic	19.39697	Durbin-Watson stat	0.683809
Prob(F-statistic)	0.000014		

Dependent Variable: $Ln(Q_{Atlantic})$
Method: Least Squares
Date: 11/30/14 Time: 20:37
Sample (adjusted): 4 28
Included observations: 25 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-94.64541	18.10085	-5.228783	0.0000
Ln(Y)	9.975228	1.719509	5.801206	0.0000
$Ln(P_{coho})$	-0.577927	0.314322	-1.838646	0.0795

R-squared	0.615607	Mean dependent var	9.992502
Adjusted R-squared	0.580662	S.D. dependent var	1.668266
S.E. of regression	1.080308	Akaike info criterion	3.104536
Sum squared resid	25.67543	Schwarz criterion	3.250801
Log likelihood	-35.80669	Hannan-Quinn criter.	3.145103
F-statistic	17.61651	Durbin-Watson stat	0.407949
Prob(F-statistic)	0.000027		

Dependent Variable: $Ln(Q_{Atlantic})$
Method: Least Squares
Date: 11/24/14 Time: 21:22
Sample (adjusted): 4 28
Included observations: 25 after adjustments
Weighting series: Ln(Psockeye)
Weight type: Inverse standard deviation (EViews default scaling)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-85.01096	26.64501	-3.190502	0.0042
Ln(Y)	9.270771	2.461882	3.765725	0.0011
$Ln(P_{sockeye})$	-1.829190	1.060838	-1.724288	0.0987

Weighted Statistics

R-squared	0.553510	Mean dependent var	9.855652
Adjusted R-squared	0.512920	S.D. dependent var	1.954339
S.E. of regression	1.388422	Akaike info criterion	3.606379
Sum squared resid	42.40972	Schwarz criterion	3.752644
Log likelihood	-42.07973	Hannan-Quinn criter.	3.646947
F-statistic	13.63661	Durbin-Watson stat	0.571250
Prob(F-statistic)	0.000141	Weighted mean dep.	9.696863

Unweighted Statistics

R-squared	0.596630	Mean dependent var	9.992502
Adjusted R-squared	0.559960	S.D. dependent var	1.668266
S.E. of regression	1.106652	Sum squared resid	26.94293
Durbin-Watson stat	0.466820		

Dependent Variable: $Ln(Q_{Atlantic})$
Method: Least Squares
Date: 11/21/14 Time: 20:39
Sample (adjusted): 4 28
Included observations: 25 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-60.62652	20.14385	-3.009679	0.0064
Ln(Y)	6.624406	1.926180	3.439142	0.0023
$Ln(P_{pink})$	-1.557298	0.563815	-2.762073	0.0114

R-squared	0.670724	Mean dependent var	9.992502
Adjusted R-squared	0.640789	S.D. dependent var	1.668266
S.E. of regression	0.999861	Akaike info criterion	2.949766
Sum squared resid	21.99390	Schwarz criterion	3.096031
Log likelihood	-33.87208	Hannan-Quinn criter.	2.990334
F-statistic	22.40660	Durbin-Watson stat	0.428455
Prob(F-statistic)	0.000005		

Dependent Variable: $Ln(Q_{Atlantic})$
Method: Least Squares
Date: 11/24/14 Time: 21:32
Sample (adjusted): 4 28
Included observations: 25 after adjustments
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-60.95558	13.24205	-4.603181	0.0001
$Ln(P_{Atlantic})$	-2.393563	1.287586	-1.858954	0.0765
Ln(Y)	7.110261	1.225229	5.803212	0.0000

R-squared	0.615106	Mean dependent var	9.992502
Adjusted R-squared	0.580115	S.D. dependent var	1.668266
S.E. of regression	1.081012	Akaike info criterion	3.105838
Sum squared resid	25.70889	Schwarz criterion	3.252103
Log likelihood	-35.82298	Hannan-Quinn criter.	3.146406
F-statistic	17.57926	Durbin-Watson stat	0.382132
Prob(F-statistic)	0.000027	Wald F-statistic	18.90349
Prob(Wald F-statistic)	0.000017		